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BASIC REQUIREMENTS IN SOVIET STANDARDS FOR ELECTRICAL EQUIPMENT

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The most important electrical engineering norms are divided into four basic categories:

1. State All-Union Standards (GOST), which establish the technical production conditions for electrotechnical plants and are compulsory for all departments

2. Departmental Technical Specifications (VTU) for manufactured parts

3. Installation regulations, which are norms regulating the design and installation of high-current electrotechnical units

4. Operating regulations, which cover requirements in the exploitation of electrical units.

There is obviously a very close connection between the norms of the categories enumerated, but they are worked out and published by different organizations which do not always coordinate their work.

The GOST are developed by the producers of electrical parts and approved by the Standardization Administration of Gostekhnika USSR, formerly the VKS All-Union Committee on Standards). The installation regulations for high-current electrotechnical units are now developed by the Ministry of Electric Power Plants and Glavelektromontazh of the Ministry for Construction of Heavy Industry Enterprises. These organizations also approve the regulations. The general electrotechnical operating regulations are developed and approved by the Ministry of Electric Power Plants. This group includes principally "Regulations for Technical Exploitation of Power Stations and Distribution Networks" (1940) and "Regulations for Technical Exploitation of Electrical Equipment in Industrial Enterprises" (1947). Moreover, many regulations and instructions for the exploitation of electrical equipment in industrial installations are published by various ministries.

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Coordination of work in compiling, judging, and approving these norms and bringing a wide circle of engineers and electricians into this important state matter is, in our opinion, the most vital task of VNITOE (All-Union Scientific and Technical Society of Power Engineers) and of our electrotechnical press, primarily the periodical Elektrichestvo.

The basic purpose of the GOST is the establishment of technical specifications for electrical machines, instruments, cables, and other complex items. The standards must not simply be fixed at the existing engineering level of the plants producing equipment; they must be one of the real levers for continuously raising the production of plants of the electrical industry to a higher technical level. As an example, the publication of the new GOST 185-47 for three-phase crane and metallurgical motors, undertaken by the VKS under prodding by consumers, speeded the establishment of production of new machines which would satisfy the requirements for electric drives designed for continuously operating machinery and aid in the introduction of three-phase, instead of direct, current in metallurgical and other applications. Of course, the standards must not be too far removed from the actual capabilities of industry or from the engineering level of allied industries (electrical insulation, metallurgical, etc.). Therefore, the GOST, like a barometer, must predict possibilities for increasing the technical level of the industry. All GOST must be reviewed periodically, at definite intervals, as a whole, and the individual paragraphs of standards can and must be reviewed as necessary (far more often than they are at present).

Reducing Operating Costs

The fundamental task arising in devising new and reviewing old GOST is to formulate technical conditions which will aid in reducing the operating cost of electrical equipment by reducing the number of operating personnel and increasing the power engineering indexes of electrical machines. Reducing the number of maintenance personnel is one of the factors for increasing labor productivity and reducing production cost; it may be attained by increasing the operational reliability of the equipment. Increasing the reliability, in turn, will reduce the necessity for large stores of spare parts which are so prevalent today in design and operation.

Reducing Capital Investments

Capital investments can be reduced by decreasing the cost of equipment and materials, for example, through mass production, which can be greatly facilitated by intelligent standardization.

Along the same lines, standards must also consider the necessity for reducing the cost of construction and installation by industrialization and the use of speed methods. The latter must include the creation of standards for complete sets of electrical equipment, e.g., complete substations and high- and low-voltage distribution units, and achieve functional unity in the supply of separately installed forms of electrical equipment which belong to one unit.

Increasing Reliability and Length of Service

It is hard to overestimate the magnitude of the economic effect which may be obtained for the country by increasing the reliability of equipment. Present-day practice in the use of cables for conduit wiring is a clear illustration. The PRTO type cable now produced by the cable industry with rubber insulation, for conduit wiring (VTU NKEP /People's Commissariat of Electrical Industry/ 128-43), is not suitable for use in shop power conduits (in the ground, foundations, etc.). It does not resist the action of water, which is always present in the conduit, or emulsions and oil, which often get into the conduit. The PR-500 and APR-500 cables are often used, but are even less suitable for these conditions. The cable often lasts only a very short time (up to several months). Moreover,

breakdown of cables sometimes causes breakdown of entire production lines and replacement of cables is very expensive. The problem of making conduit cables durable by increasing the water and oil resistance of the insulation is primary in establishing a new standard for conduit cables.

On the other hand, in the approval of a new standard, the consumers may relax existing technical specifications; they should not request unnecessary flexibility of strands in large cables for conduit wiring and should require fewer cable types by rejecting multistrand power cables, the use of which has no advantages in installation and operation but causes an increase in man-hours in the production of strands and increases the number of design dimensions, hindering large-scale mass production. This example is an illustration of possible rejection of unnecessary production requirements which may arise in the publication of standards.

Increasing the operational reliability of equipment must be done primarily by using higher quality materials and improved technological processes and by intensifying technical supervision. However, the problem must also be tackled by lowering the present norms for temperature increases. This will increase the durability of machinery and apparatus, increase their length of service, and decrease the number of breakdowns and repairs. Before the war, to save electric machine building materials, excessive current loading of equipment was permitted. Although the machines withstood the prescribed heating standards, through intensive ventilation, they did not always prove sufficiently robust in severe exploitation conditions. This especially applies to normal "general purpose" motors up to 100 kw, which were insufficiently strong when switched on to the line from standstill, when subjected to sudden overloads, or when running on two phases because a fuse had blown on one phase. Under these conditions, inevitable in operation, motors must be able to withstand brief but large overloads; in this connection, durability can be characterized by the rate of temperature increase in the windings of a braked motor, which must be considerably lower in the new series of machines than in the over-used series AD and MA motors, which have small heat capacity windings.

Another example of studying abnormal running conditions is the necessity of increasing the severity of the requirement for electric motors and voltage coils of various apparatus (contacters, relays, brakes) in the sense of uninterrupted functioning under the unavoidable variations of line voltage and frequency. The vast majority of industrial installations are supplied with electric power from the rayon networks. In existing installations the voltage sometimes varies as much as 10-20% from the rated value. Calculations on voltage deviations in factory networks show how expensive and difficult (and sometimes impossible) it is to keep the voltage at the motors within $\pm$ 5% (as laid down in GOST 183-41) under various conditions even when there is no breakdown. Therefore, consideration must be given to the possibility of raising the permissible voltage variation to $\pm$10%. Of course, this requirement relates only to the reliability of machinery operation during such deviations (heating and torque or tractive force); the preservation of the specified economic parameters (efficiency, power factor, etc.) should not be demanded.

Improving Power Characteristics

Raising the power indexes -- efficiency and power factor -- is an important requirement which concerns all electric machines. This problem has been discussed in detail in recent years in electrical engineering journals. The improvement of the power indexes of a machine can be achieved partly by improving the quality of the materials used (electrotechnical sheet steel with reduced losses) and partly by increasing the quantity of active materials (particularly copper) in a machine. However, when calling for an improvement in the power indexes of machines to decrease the losses, one must not go to the other extreme, which would lead to unjustified expenditure of materials, an increase in the weight, size, and cost of machines, and decrease the output of electric machine building plants.

The complex task of designers of electric machines and transformers is to find practical norms for electrical indexes, acceptable to both user and builder, and in the interests of the national economy as a whole.

It is important that the power indexes should be specified not only for rated conditions but also for the average running conditions, e.g., for normal electric motors up to 15 kw used mainly for driving machine tools the typical conditions is a mean load of 50%

Improving the Drive Characteristics of Electric Motors

An essential quality index of electrical equipment is its optimum adaptability to the associated mechanical equipment. A clear illustration of this is the planned increase in the torque of induction motors (in particular, minimum starting torque) in the new basic standard for electric machines.

Standardization of the Installation Dimensions of Electric Motors

The standardization of dimensions with a view to ensuring mutual interchangeability of electrical equipment used on a large scale, whether made by different plants or by the same plant in different years, is an important requirement of a GOST, resulting in reduced operating costs. Experience has shown that the absence of an all-union standard for the installation dimensions of electric motors hinders the mutual interchangeability of electric motors manufactured by plants of the Ministry of Electrical Industry, as well as those made by plants of other ministries.

Diversity of installation dimensions means either that the user has to keep a large stock of spare motors on hand or that there will be lengthy hold-ups while motors are repaired or modified. Moreover, design is rendered complicated because the designer, when planning couplings, flanges, etc., and baseplates for a motor can only go by one of the machines manufactured with the given parameters.

Even electric motors of the same series produced by different plants do not have the same dimensions. For example, the PN series of dc machines differs as to installation dimensions even when similar in other respects.

The type PN-28.5 electric motor of the Elektrosila Plant has a 30-mm shaft, whereas the Prokop'yelskiy Plant motor has a 25-mm shaft. The keyway width is 10 mm in the first machine and 8 mm in the second.

The effort, undertaken by the Ministry of Electrical Industry in 1947, to assemble all existing standardized dimensions for three-phase motors with squirrel cage rotors in one document -- the departmental specification -- is but a palliative, of interest only to factory designers and not to the user.

Standardization of installation dimensions of electric motors implies standardization of all frame dimensions, since the latter is essential for mutual interchangeability of machines under operating conditions. Standardization of frames can be accomplished by assigning a definite installation number to each group of installation dimensions.

All motors of a given type, e.g., squirrel-cage induction motors, should be shown by size according to a table of installation numbers, and these numbers should be closely related in powers and speeds by a special table. This relationship is possible only if the scale of powers of electric motors is standardized.

Standard Scale of Powers of Electric Motors

A single fixed scale of powers for electric motors was worked out in the USSR in 1927 by KhEMZ (Kharkov Electromechanical Plant) and introduced at all electric machine building plants in the country. The I, T, UT, aPRV and BAO series of motors were manufactured in accordance with this scale.

In 1932 this "old" rigid scale was abandoned under pretext of the necessity for complete utilization of all models of the existing series of machines according to temperature increase. The abandonment of the rigid scale of powers and the general revision of machine designs in the interests of maximum economy of materials, particularly copper, led to the production in 1935-36 of new series of electric machines which broke all records for utilization of materials. The following defects of these machines were revealed on service: (1) low power indexes, (2) excessively high starting currents (10-11 times rated current in the ADO series), (3) unsatisfactory torque characteristics, and (4) decreased reliability.

As for the designated power of the machine, this was established arbitrarily. The manufacturing plants set it at whatever they were able to "squeeze out" of the particular model, which often had not passed all the type tests. This caused frequent changes in catalogs, e.g., the 1937 catalog of AD electric motors was cancelled and replaced by the 1938 catalog, and the 1937 catalog of MA-200 electric motors was cancelled and replaced by the 1939 catalog.

However, even in the altered catalogs the plants continued to introduce new changes.

The Kemerovo Plant catalog for the series MA-200 motors altered the data of the KhEMZ catalog for 1939.

		Power (kw)		
Type	Speed (rpm)	KhEMZ (1939 Catalog)	Kemerovo Plant (1947 Min of Elec Ind Catalog)	Decrease (%)
MA-203-2/4	1,500	28.5	27.5	3
MA-203-2/6	1,000	19.7	18.7	5
MA-202-1/8	750	6.4	6.0	6
MA-202-2/8	750	8.3	8.0	3

The nominal outputs of motors of the new Ural series are also different from the outputs of the AD series motors (according to the 1947 catalog of TsBTI /Central Bureau of the Thermotechnical Institute?/, Ministry of Electrical Industry):

		Power (kw)		
Type	Speed (rpm)	AD Series	Ural Series (type R)	Differences (%)
41/4	1,500	4.3	4.5	+ 4
51/4	1,500	7.8	8.0	+ 2
42/6	1,000	3.5	3.3	- 6
51/6	1,000	5.0	4.5	- 10

This unjustified arbitrariness in the nominal output of electric motors is solely due to the absence of a rigid scale of powers.

From a power standardization standpoint, it is interesting to analyze the collated catalog of normal induction motors produced by plants of the Ministry of Electrical Industry in 1947. The position is as follows in the 1-2 kw range:

Power of model (kw)	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9
No of models of given power (different speeds and construction)	5	5	1	1	3	5	3	3	1	3

Total from 1 to 2 kw - 30 models

The number of power ratings and catalog models in the catalog of electric motors up to 100 kw is as follows:

	0-5 kw	0-20 kw	0-50 kw	0-100 kw
No of different power ratings	41	80	110	121
No of catalog models	105	178	232	247

The Dinamo Plant imeni Kirov revised the catalog of KP-KPD series of motors four times, sometimes increasing and sometimes decreasing the power ratings and altering the rpm for the same marking:

Yr	Type of Motor	Power (kw) (25% PV*)	Rpm (25% PV*)
1931	KP 800/447	80	400
1936	KPD 800/447	100	450
1939	KPD 800/447	95	460
1941	KPD 800/447	82	425

* PV = Duty cycle

It is obvious from the foregoing how inconvenient it is to run, design, and install motors without a standard power scale.

On the other hand, squeezing out the full power from a motor, which was done in 1931-32, hardly yields results sufficient to justify the abandonment of a rigid standard scale of electric motor power ratings.

It is well known to designers of crane drives that estimates of required power made by different methods give results which sometimes vary by as much as 30-50%. Another uncertainty is superimposed upon this difference: this is the calculated value of the duty cycle, which is subject to considerable error. Hence, the designer, when determining the power of an electric motor, uses very approximate experimental data, as a rule. Moreover, the majority of crane motors are chosen according to torque and not according to heating conditions. What, then, is the sense of squeezing the maximum power out of these motors according to temperature increase by deviating from a rigid scale of powers?

Moreover, the absence of a standard scale of powers leads to difficulties in standardization and operation of control apparatus. Even elementary apparatus such as starters can be rigidly standardized only in conformity with a standard scale of powers. The same reasoning applies to standardization of cartridge fuses.

The lack of a standard power scale and the resulting large assortment of thermal elements (relays) also presents difficulties in motor protection. Investigations have shown that, as a result, thermal protection of motors is largely ineffectual.

However, the most serious drawback of the absence of a rigid power scale is, as was stated above, the difficulty of standardizing the installation sizes of electric motors. Sometimes the thought is expressed that standardization of powers and dimensions (of frames) hinders the process of machine building. This opinion is refuted by electric machine building practice, which bears out the possibility of designing an electric motor with considerably smaller over-all dimensions by using new, heat-resisting insulating materials while preserving the dimensions of the motor. It is necessary to keep in mind the fact that the dimensions of an electric motor are determined not only by the heat resistance of the insulating materials but also by the electrical parameters -- tilting moment -- and by the mechanical parameters -- shaft and bearing sizes.

Of course, the possibility of having to change the dimensions in the future is not ruled out, but standardization of dimensions can and must be preserved for a definite time. Thereafter, the dimensions can be revised, but in an organized manner.

The next question is a vital one. Should there be a general rigid power scale for all types of electric motors (three-phase squirrel cage and wound-rotor induction motors, dc motors; stationary and crane motors; enclosed and open, etc.)? Or should each type of motor for a particular purpose have its own power scale? We are of the opinion that, as regards a new series of machines, there should be one power scale for all electric motors. Electric motors should be designed for given ratings (accepted in all branches of electric machine building), and the practice of establishing chance values for motor ratings rejected.

The problem of what the absolute values of the different ratings should be demands special examination [1, 2].

The Standardization Administration has now approved a standard power scale for 1-100 kw induction motors (GOST 4542-48). This power scale, drawn up by the Ministry of Electrical Industry as a result of the initiative of Glavelektromontazh of the Ministry for Construction of Heavy Industry Enterprises, is close to the old power scale formerly followed in the USSR, as is evident from the table below, but applies only to protected and enclosed forced-ventilated motors. It is desirable that this standard power scale be extended to other types of electric motors.

New and Old Power Scales (in kw)

1927 Scale	GOST 4542-48	1927 Scale	GOST 4542-48
0.52	-	14.5	14
1.00	1.0	20.5	20
1.70	1.7	29.0	28
2.85	2.8	40.0	40
4.50	4.5	55.0	55
6.80	7.0	75.0	75
10.00	10.0	100.0	100

Standardization of Current Scales for Apparatus

A standard scale of rated currents (OST NKTP 2705) exists for high-voltage apparatus. There is no standard for low-voltage apparatus, resulting in an unjustifiable lack of coordination. It is possible to suggest a single scale of rated currents for high- and low-voltage switching and starting-controlling apparatus, as shown in the table below.

Unified Scale of Nominal Currents for Equipment (in amp)

-	-	2	4	6
10	15	20	40	60
100	150	200	400	600
1000	1500	2000	4000	6000

NOTE: Supplementary values of nominal currents are permissible for maximum current relays, thermal relays (elements), current transformers, and fuses.

The adoption of the new scale would involve relatively few changes in the apparatus now being produced. For example, 50-amp high-voltage fuses have to be replaced by 60-amp or 40-amp fuses, 350-amp knife switches by 400-amp knife switches, etc.

The rated currents of starting apparatus (contacters, starters) must be in accordance with conditions corresponding to standard operating conditions for electric motors, namely:

1. Continuous--without subdivision into the "uninterrupted" and "prolonged" (switch off every 8 hr, three successive times) classification which are unjustifiably made in standards.

2. Repeated short-time duty (25% duty cycle) since this is the basic nominal rating for crane and metallurgical electric motors (GOST 184-47 and 185-47).

High Mechanical Durability for Electrical Equipment

It is necessary to combat the tendency manifested by some manufacturing plants to over-guarantee their products. For example, GOST 2758-44 for dc contactors lays down the number of switchings, for conditions of mechanical wear,

as one million. This is utterly inadequate for modern metallurgical drives (one of the basic consumers), where the number of switchings is 1,000 per hour and more. Thus, the GOST guarantee lasts only 1-2 months. On the other hand, a plant of the Ministry of Electrical Industry guarantees 25 million switchings for a new series of dc contactors. Such a great discrepancy between GOST requirements and the catalog data of the apparatus shows the insufficient attention paid by GOST compilers to durability of equipment.

New Designs

When new standards are being worked out, the individual parameters of equipment should be altered with care, taking into consideration that the consumer has parts produced by previous standards and the necessity for interchangeability. At the same time, the way must be prepared for new designs, which will be cheaper and more reliable.

For example, the round plug contact has been used in the USSR for many years, despite its many drawbacks and the fact that the production of a plug with a circular contact is laborious. The flat plug contact is considerably simpler to produce, and has been used successfully for connecting cords of electric irons and other appliances. Thus, a GOST must be drawn up for flat plug contacts for new equipment, but for some time facilities must be maintained for the production of round plugs for existing equipment.

Realization of Standard Requirements

It is very important that the nomenclature established by standards should be mandatory on the ministry which is the chief manufacturer of the given type of equipment. Factories cannot produce equipment with parameters differing from the established standards. But the latter do not compel the manufacturer to produce parts according to the whole scale provided by GOST. Let us take an example: In 1947 the Moscow Transformer Plant imeni Kuybyshev and other transformer plants, of their own accord and without agreement with consumers, ceased production of the intermediate powers -- 30, 75, 135, 240, 420, 750, 1350, 2400 and 4200 kva -- from the scale of ratings provided by GOST 401-41 for transformers (in contrast to electric motors, a standard scale of powers for transformers does exist in the USSR). In 1948 the production of 750-kva transformers was resumed at the insistence of the planning organization.

Our calculations, based on the formula in a previous article [1], show that the refusal of the plant to manufacture the intermediate ratings of transformers necessitates an increase of 1.13 times in installed power. The curtailment of the scale of transformers can hardly be justified on economic gounds (decrease of the number of sizes of transformers in production), especially if we consider the fact that a transformer is by nature a machine which consumes must material but not much labor in its manufacture.

In any case, one can scarcely look with favor on the practice of establishing a scale of powers in the existing GOST based on a study of the interest of consumers and producers of equipment, while permitting the producer of the equipment to put in and out of production, at his own discretion, an assortment of models from the compilation laid down in the standard. Obviously, the organ which established the standards should see to it that the appropriate ministry is in fact producing articles in accordance with the whole range laid down in the standard.

Further, it is important that the achievements of the new GOST are not wholly or partly annulled by limitations in the methodology or measuring the parameters specified by the GOST and by the presence of tolerances. For example:

1. The values of moments (torques) should be determined by measurement on the motor shaft, and not by calculation.

2. There should be no minus tolerances for the torques established in the standard, on which the designer of a drive relies when selecting an electric motor.

Checking Observance of Standards

Observance of the requirements of Soviet standards is obligatory; failure to do so is accountable before the law.

Apart from recourse to law, however, our state organs of standardization must exercise actual control over the observance of standard requirement by:

1. Periodical checks on the quality of articles in labortories of manufacturers, scientific research institutes, and higher educational institutions, or in specially created laboratories.

2. Selection of reports of type tests on the articles produced.

This is especially important with respect to mass production, in which the consumer cannot have technical control apparatus for checking the quality of production while the order is being filled. Each consumer must be able to apply to the organs controlling the observance of standards for a warranty that a certain article produced by a plant conforms with existing standards.

Organizational-Technical Tasks of Standards

Besides establishing the technical standards of electrical manufactured articles, the new standards must take into account and defend the organizational interests of the consumer. These include such problems as furnishing the consumer with complete equipment, obligations to deliver spare parts, operation and overhaul instructions, and requirements for obtaining the guaranteed service life of the equipment.

The standards should prohibit the practice, which still exists in our country, of delivering electric motors without the control equipment, starters without thermal protection, etc.

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